# SEISMIC SAFETY ELEMENT OF THE MENDOCINO COUNTY PLAN

August, 1974

WILLIAMS & MOCINE / CITY & REGIONAL PLANNING

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Emerg. relief Earthquakes " "

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## SUMMARY OF MAJOR RECOMMENDATIONS

### Coastal Areas Subject to Tsunamis or Tidal Waves

Restrict land uses to those that are economically essential (docks, fish industry and related buildings)

Prohibit construction of high occupancy and critical emergency structures in these areas (schools, hospitals, police and fire stations)

Place areas of potential inundation under flood plain zoning

### Earthquake Hazard Zones

Restrict land use across a fault or fault trace to open space use

Limit development within 100 feet of a fault trace or establish suitable setback distances

Require geological and soil engineering reports prior to development to determine if potentially dangerous or hazardous conditions exist at a particular site within a hazard zone, and to determine the degree to which adequate site preparation and engineering can overcome these potential dangers

Evaluate all dam proposals or new utility line placements in light of the possible damage to human life or property which could be caused by a natural catastrophe

Implement suitable zoning and building codes to protect present and future residents

### County Wide

Have available for public inspection maps showing hazard zone areas in Mendocino County

Disseminate emergency preparedness information and stress measures which individuals can take in a time of natural catastrophe

Promote regional or statewide insurance coverage for residents of geologically hazardous areas

## INTRODUCTION AND LEGAL REQUIREMENTS FOR ELEMENT

In February 1971, the San Fernando Valley in Los Angeles County was shaken by violent earthquake tremors; major damage was done to public buildings and freeway structures as well as private buildings. Serious damage done to a reservoir dam above the valley necessitated evacuation of thousands of families until the reservoir could be drained and threat of further devastation by flooding was removed. An aftermath of this extremely serious disaster was the passage of Section 65302 (f) in California law which requires each City and County to prepare a Seismic Safety Element of its General Plan.

The basic intent of the Element as required by the law is to reduce loss of life, injury, damage to property and economic and social dislocation from future earthquakes. This requires identification of those areas subject to seismic hazards such as surface rupture from fault movement, ground shaking, ground failures and seismically induced waves. Finally, an evaluation of risk equated with acceptable land uses and regulations for risk areas must be made.

Several guidelines for preparation of Seismic Safety Elements have been established and this report has made use of them. These include Suggested Earthquake Guidelines for the Seismic Safety Element of the General Plan, Governor's Earthquake Council, 1972; Draft Guidelines for Local General Plans, Council for Intergovernmental Relations, 1973; Geology and Earthquake Hazards: Planners' Guide to the Seismic Safety Element, Association of Engineering Geologists, 1973; Guidelines for Developing a Seismic Safety Element, ASPO, 1974. Additionally, the findings and recommendations of this report are directly related to the Safety Element and the Open Space/Conservation Element of the Mendocino County General Plan. It also relates to the policies established by the citizens of the County and listed below. In a more general sense, the Seismic Safety Element is also related to the Land Use and Housing Elements of the County Plan. The Guidelines developed by the Council on Intergovernmental Relationships advises that... "Communities with extensive open areas and areas subject to urbanization may wish to focus on natural seismic hazards and the formulation of land use policies and development regulations to insure that new development is not hazardous." This is most appropriate for Mendocino County and this report does focus in that direction rather than on "structural hazard and disaster planning" which is recommended for fully developed urban communities.

Policy Statement, Mendocino County Citizens' Committee

- Residents of Mendocino County are aware of the threats of earthquakes and other natural hazards. The size of the County with its vast forested areas, steep hill and valley terrain and heavy rainfall make it necessary to identify the potential hazards associated with each area.

- Geologically hazardous areas need to be mapped and made a matter of public record available to sellers, buyers and users of land and structures. Detailed studies of any particular site must be made a part of any land development plan.

- Where man-made or naturally hazardous areas (steep hillsides, fault zones, and areas of unstable soil) have been identified, special building standards and soil engineering requirements should be established and enforced to reduce future risks.

- The emergency disaster plan must be implemented to maintain order, and provide for the needs of displaced, injured and isolated persons and to insure supplies of food and water should normal channels of distribution be severed or sources contaminated in a future disaster. The Plan must include both necessary public agency actions and instructions for private action in time of disaster.

# GENERAL CONSIDERATIONS OF EARTHQUAKE HAZARDS

## Statewide Considerations

California is called earthquake country. It is located on what is known as the "ring of fire," the volcanic belt which roughly coincides with a line drawn around the edge of the Pacific Ocean (the circum-Pacific seismic belt). Eighty percent of the world's earthquakes occur along this belt. Other countries situated along this belt, such as Japan and the Aleutian Islands, have more frequent earthquakes but, for the last 60 years, California has experienced a potentially destructive earthquake on the average of one every two years, according to the California Division of Mines and Geology.

Earthquakes are caused by movement of crustal material as the rocks of the earth adjust to tectonic forces. Recent geological data gathered from investigation of the world's ocean floors indicate that the surface of the earth is composed of a number of more or less rigid plates. These plates are "floating" on a "plastic" zone of molten rock material. The frequency of earthquakes is highest where two plates are being pushed against each other or where one plate is overriding another. The stresses built up in the rocks as the plates are pushed into each other are released when the strength of the rock is exceeded and the result is an earthquake. Faults are usually manifested on the surface as a fault trace or fault line.

The American plate includes both North and South America and extends from the Mid-Atlantic ridge to the western coast of the continents. The San Andreas fault is a part of the western boundary of the American plate, according to some geologists. The crustal material west of the San Andreas fault is part of the Pacific platewhich is moving northwest.

Earthquakes cause various geological processes that can cause severe damage to structures and danger to people. The Alquist-Priolo Geologic Hazards Zone Act requires that state geologists provide special study zone maps which delineate all potentially and recently active faults which constitute potential hazards to structures. Faults crisscross the surface of the earth. Most have not moved for hundreds of thousands or even millions of years and can be considered

inactive. Others show evidence of current activity or have moved recently; these are considered active faults. A fault or fracture zone may be from several feet to several miles long. Fault displacement occurs when the earth on one side of a fracture zone moves in relationship to the earth on the other side but the hazards involved are not limited to the fault line where the surface evidence of movement can be viewed. The hazards can be grouped into four main categories: ground shaking, surface faulting, ground failure, and seismically induced water waves. Each of these natural phenomena is examined briefly in the following paragraphs.

## Ground Shaking

Earth tremors and shaking are felt far beyond the actual area of major faulting and this causes by far the greatest damage in an earthquake. With continuation of present locational and building practices, the Division of Mines and Geology estimates that damage in California from ground shaking is expected to be 21 billion dollars between 1970 and 2000. Shaking is generally accompanied by minor earth movements. If this is in excess of an inch, the combined effects of shaking and movement on a structure can be catastrophic. The extent of damage will depend somewhat on design and construction. Problems can arise from any one or a combination of the following:

- failure of structure due to shaking.
- foundation failure due to soil bearing failure.
- differential settlement of structure due to soil compaction.

## Surface Faulting

While considerable attention is given to location of surface faults (since this is visible evidence of their existence and invaluable in many respects) it is interesting to note that less than one percent of earthquake damage is caused by surface faulting, according to the Department of Mines and Geology. Faults must be identified because, very obviously, a structure built over a fault line will be torn asunder if earth movement occurs; a structure just a few feet away from the actual movement may ride out the quake with less damage though certainly it would be in a precarious position. Earthquake magnitude is measured at the point on the earth's surface directly above the point of origin of the quake. This is a point along the fault line and is called the epicenter. The Richter Scale is at present the most common measure of magnitude but an expected modification will measure intensity as well. The two scales are compared below and both are referenced in this report.

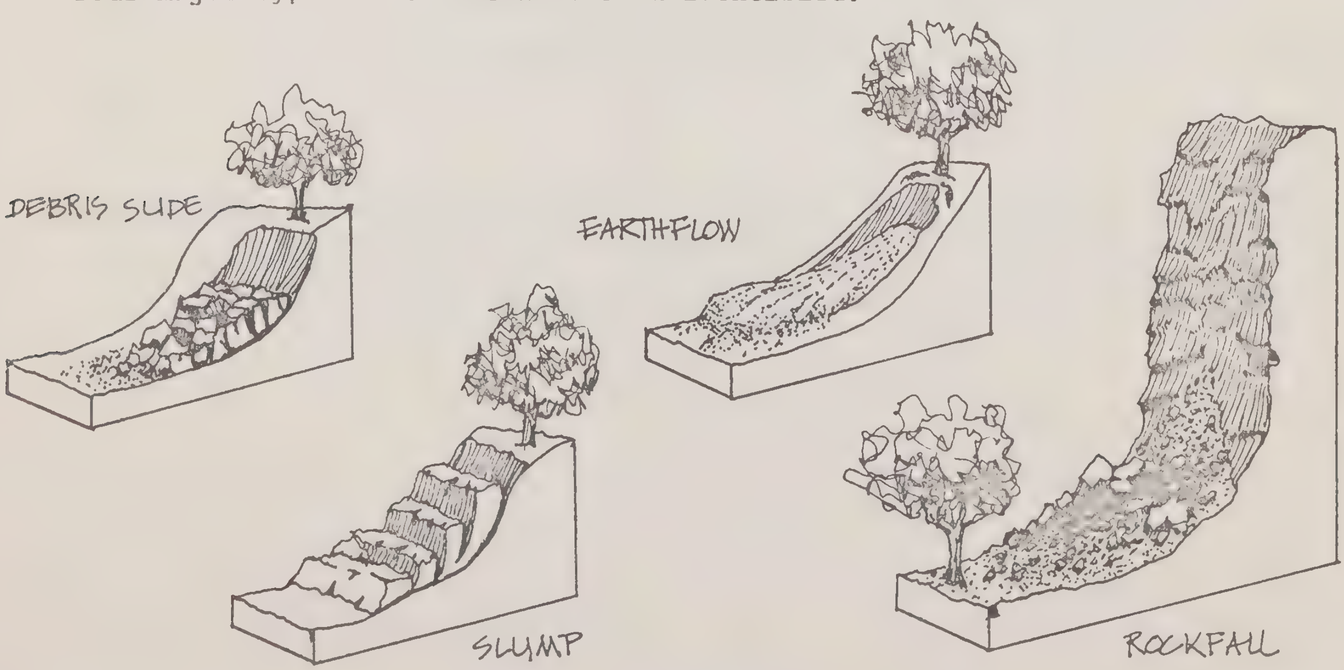
COMPARISON OF MAGNITUDE AND INTENSITY

| Richter Magnitude | | Expected Modified Mercalli Maximum Intensity (at Epicenter) |
|---|---|---|
| 2 | I-II | Usually detected only by instruments |
| 3 | III | Felt indoors |
| 4 | IV-V | Felt by most people; slight damage |
| 5 | VI-VII | Felt by all; many frightened and run outdoors; damage minor to moderate |
| 6 | VII-VIII | Everybody runs outdoors; damage moderage to major |
| 7 | IX-X | Major damage |
| 8+ | X-XII | Total and major damages |

A potential active fault has been defined by the state as any fault considered to have been active during Quarternary time (last 3,000,000 years) - on the basis of evidence of surface displacement. An exception is made when a Quarternary fault has been determined from direct evidence to have been inactive before Holocene time (last 11,000 years). The average interval between potentially damaging earthquakes (magnitude 6.5 or greater on the Richter Scale) is not predictable within definite limits. Two sources say that it is in range of several tens of years to several hundred years (Wallace, 1970; Buchanan, 1970).

Ground Failure

Earthquakes and landslides go hand in hand in California. The greatest chance of land failure is near the epicenter of the quake and will depend additionally on the state and kind of rock materials involved (Morton and Streitz, 1967). Water absorption quality of the soil, cleavage and orientation of rocks are factors. Four major types of slides have been identified.



## Structural Safety in Earthquake Risk Areas

The table following equates risk with certain types of buildings and indicates added costs to reduce risk to acceptable levels. It shows that certain types of buildings may be very much more costly in high risk areas than in safe or minimum risk areas. Although the information is very general, it is a useful guide and demonstrates the need for considering the seismic safety factors in land use planning.

## Seismically Induced Water Waves

Tsunamis or tidal waves are great ocean waves generated by earthquakes or, less commonly, by large submarine landslides. These affect only coastal areas and streams emptying into the ocean. In the deep ocean the wave length from crest to crest may be hundreds of miles long although the wave height from trough to crest may be only a few feet. A tsunami cannot be seen from the air or felt aboard ship in deep water but the energy it contains can be impressive. As a tsunami enters the sloping region of the continental shelf and its shallow water the wave length diminishes and height generally increases. If the tsunami precedes a normal low tide, wave height may instead diminish. Finally, however, waves reaching heights of more than 100 feet will slam into shore doing great damage. The northern California coast was struck by a severe tsunami after the Alaskan earthquake of 1964. This was the most destruction reported in 100 years. Damage at Albion River was reported at half a million dollars and at Noyo River of one million. Total damage in California was over thirteen million dollars and thirteen lives were lost. Seiches are waves induced by earth movement occurring within enclosed lakes, reservoirs, bays and rivers. They generally have an amplitude of one foot or less but in shallow areas or where the water is constricted, waves as great as 20 or 30 feet can occur (McCullock, 1966).

The process of assessing the hazards from tsunamis and seiches is difficult and not very precise at this time. However, there seems to be a recurring potential for catastrophic occurrence where the phenomonon has occurred in the past.

## SCALE OF RISKS

| | Level of Risk to Public | Kinds of Structures | Extra Project Cost Probably Required to Reduce Risk to an Acceptable Level |
|---|---|---|---|
| Failure of a single structure may affect substantial populations | Extremely High | Structures whose continued functioning is critical, or whose failure might be catastrophic: nuclear reactors, large dams, power inter-tie systems, plants manufacturing explosives. | No set percentage (whatever is required for maximum attainable safety) |
| | Slightly lower than above | Structure whose use is critically needed after a disaster: important utility centers, hospitals, fire, police and emergency communication facilities, and critical transportation elements, such as bridges & overpasses; also smaller dams. | 20 to 25 percent of project cost |
| Failure of a single structure will affect primarily only the occupants | Possible High Risk to <u>occupants</u> | Structures of high occupancy, or whose use after a disaster will be particularly convenient: schools, churches, theaters, large hotels and other high-rise buildings housing large numbers of people, other places normally attracting large concentrations of people, civic buildings such as fire stations, secondary utility structures, extremely large commercial enterprises, most roads, alternate or noncritical bridge and overpasses. | 10 to 15 percent of project cost |
| | An "ordinary" level of risk* | The vast majority of structures: most commercial and industrial buildings, small hotels and apartment buildings, and single-family residences. | 1 to 2 percent of project cost, in most cases (2 to 10 percent of project cost, in a minority of case |

*"Ordinary" risk: Resist minor earthquakes without damage; resist moderate earthquakes without structural damage, but with some nonstructural damage; resist major earthquakes of the intensity or severity of the strongest experienced in California, without collapse, but with some structural as well as nonstructural damage. In most structures it is expected that structural damage, even in a major earthquake, could be limited to repairable damage. (Adapted from <u>Scale of Acceptable Risks</u> of the Structural Engineers Assoc. of California.) TRI-Cities Seismic Safety and Environmental Resources Study 1974

# CHARACTERISTICS OF MENDOCINO COUNTY

## Geological Background

Mendocino County can be divided into two main geological areas

- Coastal Range - Cretaceous, Early Tertiary
- Eastern Belt - Jurassic, Cretaceous - Franciscon Formation

The Coastal Range extends from Cape Mendocino as far south as Marin County (Barley, Irwin and Jones, 1964). From Cape Mendocino to Point Arena the Pacific Ocean is the visible western boundary of the coastal range. South of Point Arena the San Andreas Fault separates the "coastal belt" from the Salinian Block. The eastern boundary of the coastal belt is the central belt of the Franciscan Formation. The belt is from 10 to 25 miles wide and consists of greywacke sandstone, shale and minor conglomerates.

The Franciscan Formation is composed of marine sedimentary rocks and associated volcanic metamorphised sandstones and shales.

Coastal belt rocks are somewhat younger than eastern belt rocks. There is also a difference in the mineral composition of the rocks which can be seen in the differences in appearance of the weathered rocks. Weathered coastal rock is light, yellowish-brown while eastern belt rock is a dull earthy brown.

Rocks of both belts are, with few exceptions highly folded, faulted and fractured. There are zones up to a few miles wide and several miles long composed primarily of highly crushed rock formed as a result ot tectonic stresses of the earth. These zones are referred to as melange and are quite landslide prone. This is a characteristic of the eastern belt.

There are occasional isolated areas of alluvial deposits of various sizes found throughout the County. Little Lake Valley, parts of the Ukiah Valley, Potter Valley, parts of Hopland, parts of Anderson Valley, Eden Valley,

Round Valley, Laytonville, Covello Area have such alluvial deposits. These deposits are non-marine, mildly consolidated sands, silts, clays and gravels of Pleo-Pleistocene Age.

Other isolated geologic rock types are found at Little Red Mountain and in the Bright Ridge, Eden Valley area. These are Mesozoic Ultrabasic intrusive rocks and are of limited extent in the County.

Geologic rock types are mapped and rated as to slide potential on the Hazard Map. Generally the eastern belt is most prone to sliding though the valley floors are relatively stable. The description above is very general and no conclusions concerning small areas of the County or individual sites can be made. The fact that rocks of both geographical areas of the County are generally "folded, faulted and fractured" and there are significant zones of landslide-prone melange, points out the need for soil testing and geological field investigation wherever large scale or important development is proposed. Access to a site as well as the safety of the site itself must be insured.

## Geotechnical Hazard Zones

During the evaluation of seismic events and geologic features it became apparent that there were four large areas which had similar bedrock and soil characteristics, ground rupture potential, ground stability and flooding characteristics. These areas of similar geotechnical characteristics are called "Geotechnical Hazard Zones."

The boundaries of the Hazard Zones are a matter of judgment and can not be precisely drawn. However, each zone can be considered separately for regulation through Grading and Zoning Ordinances and Planning regulations governing land development. Each zone and related hazards are described separately in the following sections:

Hazard Zones

| | |
|---|---|
| Zone I | San Andreas Fault Zone |
| Zone II | Healdsburg Fault Zone |
| Zone III | Central County Area |
| Zone IV | North County Area |

Zone I - The San Andreas Fault Zone. Description of Major Fault and Hazards

This zone is subject to all four types of seismic hazard: ground shaking, surface faulting, ground failure and seismically induced waves. Conditions and hazards in Zone I are fully described and except for the section on waves, much of the material applies to all parts of the County. The other zones are therefore described but information included in Zone I section is not repeated.

Faulting---In 1906 the earthquake which devastated San Francisco was felt and registered as far north as Point Delgada just north of the Mendocino County line. At Fort Bragg, almost every brick building was destroyed and many frame buildings were shifted off their foundations.

C.R. Johnson, founder of the town of Fort Bragg and of the Union Lumber Company, was quoted in The Noyo Chief as follows:

> On the morning of April 18, 1906, the earth rocked so violently that it seemed as if some giant had taken it in his hands and was shaking it relentlessly. When it was all over, the mill was off its foundations and badly wrecked; and a large part of Fort Bragg was destroyed. As in San Francisco the quake itself was bad --- but the fire which followed was vastly worse and did most of the damage.

The 1906 quake was due to movement along the San Andreas Fault, the major fault running north and south near to or on the California Coast. The map on the preceding page shows the San Andreas Fault cutting through the south west portion of the County.

North of Point Arena the San Andreas Fault passes under the sea and, if projected northwest along its trend line, it does not again intersect the shoreline. Sea-floor geological and geophysical data are insufficient to ascertain whether or not the Shelter Cove Trace connects with the undersea San Andreas Fault; isoseismic data for the 1906 earthquake and recent offshore reflection survey

work suggest that the fault (or a branch) turns northward near Point Arena and connects with the trace at Shelter Cove. (The small traces and faults in the north County have not been located with sufficient precision to map. The Shelter Cove trace is one of these).

It has been suggested by geologists (Allen, 1965) that the section of the San Andreas which broke in 1906 and another section further south near Fort Tejon are characterized by occassional great quakes rather than frequent smaller (though still potentially damaging) earthquakes and tectonic creep. In a general way then, this seems to indicate that the area would be subject to infrequent but severe shocks. Only a few small earthquakes have occurred in this area since 1906. As stated earlier in the general information section, earthquake intervals cannot be predicted within short time periods; however, there is a very real possibility of a major earthquake ranging in magnitude 6.5 to 8 within the next 25 to 50 years in this portion of Mendocino County (Wentworth, 1972) and Zone I is considered as having the highest potential for disaster of the four Zones in the County.

Careful land use planning and regulations for building and development will permit development to continue and reduce risk to acceptable levels and it is crucial that this be done. The area in Mendocino County most affected by any movement of this major fault is along the Gualala reach, the terrace west of the fault between Fort Ross and Point Arena, where the fault is on-shore.

A brief description of movement during the 1906 quake will illustrate the potential problems of this area. This part of the coast experienced intensities of 7 on the Richter Scale and IX to X on the modified Mercalli scale. Horizontal displacement ranged from ten to sixteen feet and there was also minor vertical displacement, generally not exceeding one foot. All roads and railroads crossing the fault were torn up and rendered impassable; all structures straddling the fault line were either destroyed or badly ruptured.

Between Shelter Cove and Point Arena the San Andreas fault lies from five to 25 miles west of the coast, depending on whether one assumes the fault connects with the Shelter Cove trace of 1906 or projects northwestward from Point Arena. A strong shock occurred in 1898 near Point Arena, yielding intensities VIII to IX or between 6 and 7 on the Richter scale, and damaging Mendocino, 25 miles away. Earthquake history along this part of the north Mendocino coast however depends mainly on the earthquake of 1906. At that time, horizontal ground rupture was observed on fault traces in a zone about three miles long and passing within a mile of Point Delgada (Shelter Cove). Offset was not measured mainly due to a lack of intersecting physical features such as roads or fences.

The northern stretch of coast from False Cape to Point Delgada is very rocky and solid and earthquake risks are somewhat less than in other parts of the Zone, though, in limited areas, slides may occur.

Ground Failure---Land slides in the coastal belt are usually slumps and earth flows. This is due to the geological history of the area and the high annual rainfall (in comparison to the rest of the County), steep slopes, dense vegetation, and intense weathering. Roads heading inland do show evidence of recent sliding and an earthquake could cause serious road blockage. Highway 1 could still be damaged by slides associated with a major quake.

Grading for hillside development can trigger old land slides and initiate new ones. Tragic consequences of unwise hillside use have resulted from such actions in the Bay Area and in Los Angeles where houses have slid down hill. The steep slopes of the San Andreas Fault Zone should be protected both from an aesthetic standpoint and from that of public safety.

Most active slides have total movements yearly ranging from a few inches to 20 feet. In rare instances annual movements of about 300 feet have occurred. When these cross highways, railroad or utility lines, sizeable economic loss occurs. This risk of slides should be taken into account when locating lines or development which will require such installations.

Ground Shaking--This is a general hazard in all the San Andreas Fault Zone. As mentioned earlier, the rocky stretch along the north coast is less subject to hazard than other areas. The fault map shows generalized areas of major risk and special regulations should cover location and construction of all buildings in these areas. Particular care must be used in locating structures necessary for public safety and those which are for public assembly, including schools. Special construction and location regulations are needed for these areas. Soil testing and other field investigations should be required before permitting construction of major projects, either public or private.

Waves--The coast is of course the only area of the County subject to tsunami hazard. The following Table and the map show the areas of concern.

The seiche hazard for enclosed bodies of water is not a real concern anywhere in the County. The largest enclosed body of water is Lake Mendocino within the San Andreas Fault Zone. The normal pool elevation of the lake is 738 feet and spillway eleveation is 765 feet. Under normal conditions, then it would appear there is a reasonable margin of safety in terms of any potential seiche damage.

## TSUNAMI HAZARD

### MENDOCINO COASTAL AREA

| | Name | Hazard |
|---|---|---|
| 1. | Arena Cove Area | Potential Harbor Damage |
| 2. | Manchester Beach State Park to Iversom Point | Special Caution During an Alert* |
| 3. | Albion River | Damage to Boats and Harbor due to swift current |
| 4. | Noyo Bay Area | Harbors - Damage to Boats and harbor facilities due to swift current |
| 5. | Mackerricher State Park to Ten Mile River | Special Caution During an Alert* |

* Area should be cleared if flood tide and tsunami are coincident.

Source: California Division of Mines and Geology
State of California Department of Conservation
Seismic Safety Information - 1974

Expected Recurrence Rate---Wave height and damage due to tsunamis in California, regardless of where they originate, have always been greatest at Crescent City in Del Norte County. Using information recorded there and at the Presidio in San Francisco curves have been constructed which suggest future tidal wave action (Weigel 1970).

The curve for San Francisco suggests that a wave height or "run up" equal to or greater than 6.5 feet can be expected once in 50 years. The curve for Crescent City suggests a wave height of about 17 feet or greater each 50 years or about 26 feet every 100 years. The "run up" in 1964 of 21 feet had a recurrence of about 80 years (Dept. of Mines and Geology 1972).

While none of these available statistics directly cite Mendocino County, all apply to it since it is located between the two stations used for projection.

Tsunami Warning System---The U.S. Coast and Geodetic Survey, National Oceanographic and Aerigraphic Administration, Dept. of Commerce operates a Seismic Sea-Wave Warning System. The system uses seismographs to detect and locate earthquakes; tidal gauges to detect whether tsunami waves have indeed been generated; and automatic alarms to warn of any tsunami that is detected.

From a network of stations distributed throughout the Pacific Ocean basin, the travel and arrival times for individual tsunamis are plotted with an accuracy of within a minute and a half per hours' travel time. Warning of an approaching tsunami is communicated to the appropriate federal agencies and to the U.S. Weather Bureau networks.

The Director of Civil Defense has the responsibility and authority to initiate emergency preparedness acts in the County in the event of an oncoming tidal wave. Emergency procedures have been outlined in the Mendocino County Emergency Plan.

Under the present warning system, at least several hours are available to evacuate the population to a safe place and make other emergency preparations.

In the future, as the inland valley increase their population and become more urban, more dams and reservoirs will be needed to insure a quality water supply. Conceivably seiches on such inland bodies of water may be a problem some day. California law recognizes the catastrophic effect of dam failure and requires all responsible agencies to prepare maps showing potential inundation areas. These must be used in land use planning and in plans for disaster preparedness. No area should be permitted to urbanize unless a water supply can be provided without creating a potential hazard. This consideration applies not only to the valleys in the San Andreas Fault Zone, but to all Zones.

Zone II - Healdsburg Hazard Zone. Description of Faults and Summary of Hazards
The Healdsburg Fault runs south and east from Boonville to the County line. The fault, like the San Andreas, is capable of generating a magnitude of 6 or greater on the Richter scale. The Natural Hazards Map shows that Zone II is in the eastern belt of relative soil instability with most of the area rated 6 (most subject to land slides). Level valley floors are naturally given better stability ratings than the steep valley walls and mountainous areas. Land slides and evidence of soil instability can be observed widely throughout the southern County. Cutting and grading hillsides for subdivision appears extremely risky in many locations within the relatively earthquake prone Zone associated with the Healdsburg Fault. Steeply sloped and unstable valley walls and the alluvial deposits of the valley floors make the area subject to a combination of hazards. The chief hazard is landsliding and the secondary hazard is soil liquefaction due to accumulation of water in the alluvial soil. The tendency for sliding and liquefaction is strengthened by the naturally heavy rainfall in the County. Road building and maintenance in steep instable terrain

has always posed problems and in an earthquake area such as Zone II particular care must be exercised. Maintenance of utility lines is also difficult in such areas. Where soil and terrain preclude safe and sure access, large scale urbanization must also be precluded. Land use planning for inland valleys must take these factors into account.

The complex geological conditions found in the County result in varying risks between valleys and even within one valley, and regulations will vary accordingly. Since the major concentrations of people are in the inland valleys, regulations are particularly needed and studies must be made which will lead to protection of existing and future populations. The fault line or rift of course constitutes a specific hazard.

Zone III - The Central County Hazard Zone. Description of Faults and Summary of Hazards

There are a number of small faults in the eastern Franciscan rock formation. Most of these are generally considered to be inactive but judged capable of generating earthquake magnitudes of from 1 to 5 on the Richter scale. One fault runs some twenty miles in a north west direction about ten miles north east of the Ukiah Valley; another stretches for some fifteen miles in a north-east direction and passes about a mile north of Willets. Ten miles east of Laytonville there is a small fault; on the west there is a longer fault stretching about thirty-five miles in a north east direction. Soil stability is poor (rated 6) in much of the area. Although the faults are at present considered inactive, significant numbers of people are living in areas which will be affected if movement does occur. Earthquake risk is generally lower in Zones III and IV than in Zones I and II but slides in areas such as this can be triggered by even minor earth movement or by heavy rainfall, weathering and other natural causes. Unwise cutting and grading of hillsides for development increases the slide risk enormously. As urbanization continues, the hazards from shaking, land failure and earth movement will increase unless development controls

to minimize risks such as those outlined for the Healdsburg Fault Zone are implemented. The map shows general conditions for the area.

Zone IV - North County Hazard Zone. Description of Faults and Summary of Hazards

The Natural Hazards Map shows a fault at the north end of Redwood Valley. It stretches about twenty-five miles in a south-east direction. A second small fault has been identified about eight miles to the east of the first one. As with the other inland faults, it is not possible to predict future movement along the faults in the north County but their nearness to populated areas cannot be ignored. Large portions of the north County inland area are rated 6 and seismic action even or low magnitude could trigger damaging slides. Future land use planning and regulations for development and construction must take these conditions into account.

## CONCULSIONS AND RECOMMENDATIONS

The fault information and related information given here is not sufficient to evaluate hazards for specific development. It is intended to inform decision makers as to the potential hazard involved in land use decisions and to indicate the types of controls needed to minimize risk. Special studies will have to be made for particular sites within a special fault zone prior to development to determine if a potential hazard from fault movement or land slides exists with regard to proposed structures or its occupants. California law states that in no case can structures be located across a fault trace.

Considering the size of the County, the size of the staff available to administer new regulations and the cost to the County and to the residents, it may reasonably be expected that there will be a time lag of perhaps a year or two or more before some or any of the actions proposed here can be implemented. However, the recommendations are presented here to provide the County with reasonable alternatives which can be implemented to protect present and future residents of Mendocino County.

### Coastal Areas subject to Tsunamis

Stringent land use controls should be applied in areas subject to tsunamis (tidal waves) and seiches (waves on lakes or reservoirs). These controls might include the following:

1. Restrict land uses to those that are economically essential (docks, fish industry related buildings, etc.).
2. Warn builders, owners and occupants of potential hazards.
3. Prohibit construction of high occupancy and critical emergency structures (for example, schools, hospitals, police and fire stations).
4. Place areas of potential inundation under flood plain zoning.
5. Institute appropriate systems to warn of impending hazardous conditions particularly at beaches used or intended for public use.
6. Adopt and implement evacuation plans for areas subject to tsunamis.

Coastal Areas Subject to Ground Shaking or Ground Failure - Earthquake Hazard Zone

The San Andreas Fault dips into the sea just north of Point Arena and this area of the coast is the most likely area in the County to be affected by earthquakes. However, it is probable that a major earthquake (intensity 6.5 or above) would be felt all along the entire coastal area. Measures which may reduce the risks to life and property to an acceptable level include:

1. Restrict land use across a fault or fault tracing to open space use.
2. Limit and regulate type of development within 100 feet of a fault trace or establish building set back distances from active fault traces. The amount of setback might differ with the type of faulting and deformation expected.
3. Establish and/or coordinate various capital improvement programs and projects aimed at eliminating high risk situations. These may include regional or state level high risk insurance programs.
4. Develop inspection and evaluation criteria for evaluation of existing structures.
5. Revise or amend existing zoning ordinances, building code standards and associated regulations to include earthquake hazard reduction measures.
6. Designate appropriate agencies or persons to coordinate emergency disaster procedures.

Seismic Hazard or Geological Hazard Zones in the Inland Valleys

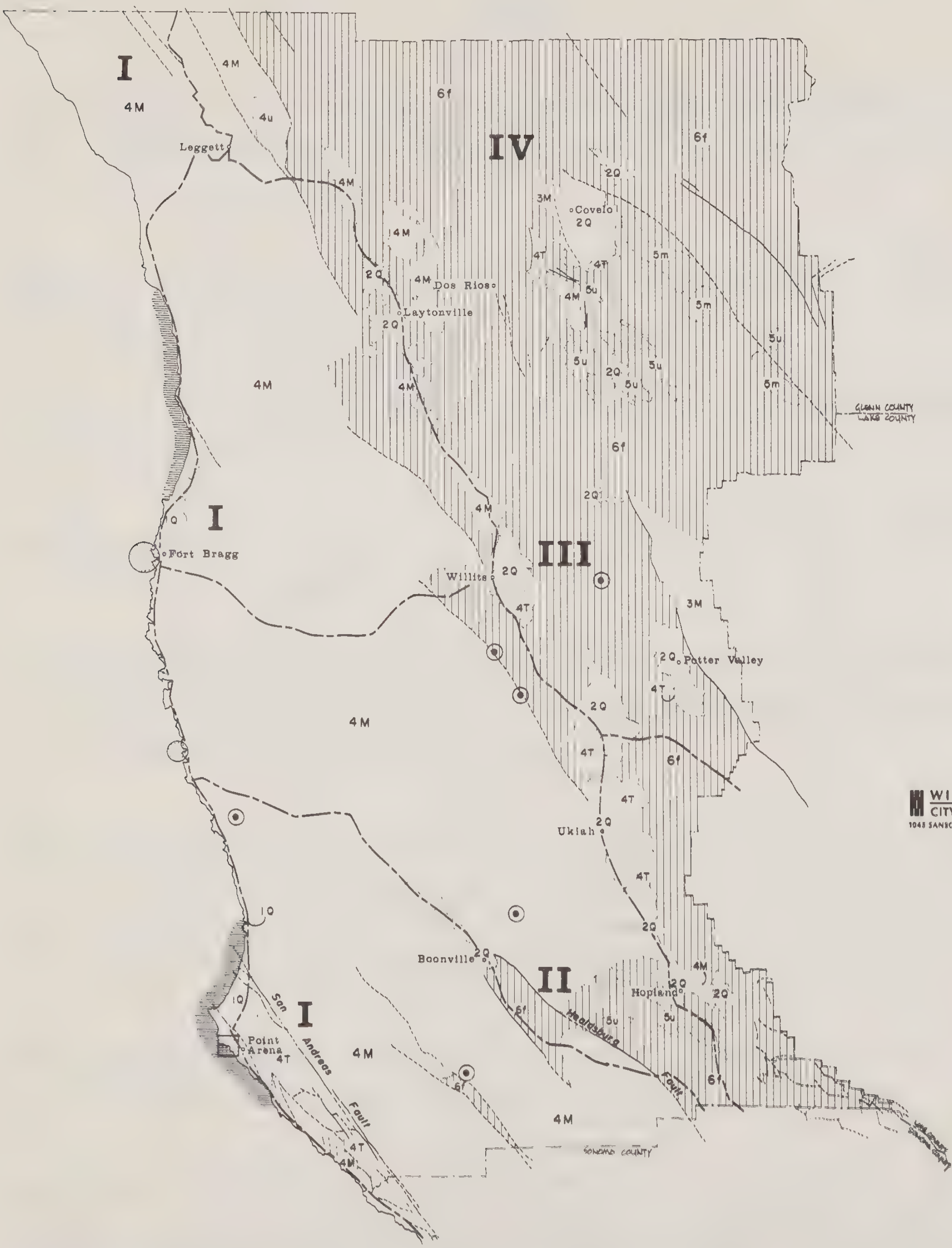
In geological hazard zones or seismic hazard zones, which have been identified and others which may be identified as a result of future study, the following controls should be implemented as needed:

1. Geological and soil engineering reports should be required to determine if static and dynamic hazardous conditions either do not exist or can be overcome by site preparation work or engineering. These studies should be made prior to approval of development plans.
2. Evaluate during the public hearing phase or before, if possible, the future location of utility lines and roads to determine if

alternative locations may prove less costly when compared to constant repair cost as on roads damaged by repeated landslides or replacement cost of utility lines after a major catastrophy. It may be impossible to adequately service a community without in some instances crossing a geologic hazard zone area.

3. Warn present owners, developers, and occupants of geological hazards in their area. This information should also be readily available for people seeking to buy land in the County.
4. Promote regional or state wide insurance coverage for residents of geologically hazardous areas.
5. Implement suitable zoning or building code standards.
6. Publically identify local agencies and individuals who will have the responsibility for coordinating Emergency Disaster Plans and their implementation.
7. Adopt and implement exact evacuation routes.

# MENDOCINO COUNTY GEOLOGIC HAZARDS
## Seismic Safety Element

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MILES

WILLIAMS & MOCINE
CITY & REGIONAL PLANNING
1045 SANSOME STREET, SAN FRANCISCO, CA 94111

SEPTEMBER 1974

### seismic features

FAULTS

FAULTS approximate location

EARTHQUAKE EPICENTER 1934 to 1971

source: Cal. Div of Mines and Geology 1972

### hazard zones

I SAN ANDREAS FAULT ZONE

II HEALDSBURG FAULT ZONE

III CENTRAL COUNTY ZONE

IV NORTH COUNTY ZONE

### tsunami hazard

SEVERE HARBOR DAMAGE

LESS SEVERE HARBOR DAMAGE

POTENTIAL HARBOR DAMAGE

LOW COASTAL AREAS
AND PUBLIC BEACHES

source: Cal. Div. of Mines and Geology 1972

major roads

### landslide hazard

BASED ON GENERALIZED GEOLOGIC UNITS

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|

LEAST LANDSLIDES — MOST LANDSLIDES

GEOLOGIC TYPES

Q Quaternary sediments

T Tertiary & Tertiary-Quaternary sediments

u ultrabasic rocks, mostly serpentine

M Mesozoic sedimentary rocks except Franciscan Formation

f rocks of Franciscan Formation

m metamorphic rocks

source: Radbruch, USGS 1970

## GLOSSARY

Amplification: The increase in earthquake ground motion that may occur to the principal components of seismic waves as they enter and pass through different earth materials.

Damping: Resistance to vibration that causes a progressive reduction of motion with time or distance.

Epicenter: That point on the earth's surface directly above the point of origin of an earthquake.

Geologic surveys: The use of one or more techniques of physical measurement to explore earth properties and processes.

Hazardous building: Building considered unsafe owing to poor design, poor construction techniques or material, defects in foundation conditions or damage from any one of several possible causes.

Intensity: A subjective measure of the force of an earthquake at a paricular place as determined by its effects on persons, structures, and earth materials. The principle scale used in the United States today is the Modified Mercalli as modified by Richter in 1956 and rearranged. (See Table

Left-lateral movement: A general horizontal movement in which the block across the fault from the observer has moved to the left.

Magnitude: The rating of a given earthquake is defined as the logarithm of the maximum amplitude on a seismogram written by an instrument of specific standard type calculated to be a distance of 62 miles (100km) from the epicenter. The scale is open ended but the largest known earthquake magnitudes are near 8 3/4. Because the scale is logarithmic, every upward step of 1 magnitude unit increases the recorded amplitude by 10 (after Richter 1958, p. 10).

Microearthquake: An earthquake having a magnitude of 2 or less on the Richter scale.

Microseismic event: Earthquakes or man induced vibrations observable only with instruments.

Modified Mercalli: See Intensity.

Right lateral movement: Generally horizontal movement in which the block across the fault from an observer has moved to the right.

Sag pond: Enclosed depression, generally occupied by water, formed when movement along a fault has disturbed the surface or subsurface continuity of drainage.

Sand boils: Turbid upward flow of water and some sand to the ground surface resulting from increased ground water pressures when saturated cohesionless materials are compacted by earthquake ground vibrations.

Sand ridges: Low ridges of sand extruded along fissures caused by ground cracking and expulsion of water and sand by liquefaction.

Sand volcano: A low, cone-shaped accumulation of sand produced by the upward expulsion of sand-laden water from compaction of saturated cohesionless materials subject to earthquake ground vibrations.

Scarp: A cliff or steep slope formed by a fault, generally by one side moving up relative to the other.

Seismic: Pertaining to an earthquake or earth vibration, including those that are artificially induced.

Seismograph: An instrument that scribes a permanent continuous record of earth vibrations.

Seismometer: A device that detects vibrations of the earth, and whose physical constants are known sufficiently for calibration to permit calculation of actual ground motion from the seismograph.

Shear: A mode of failure whereby two adjacent parts of a solid slide past one another parallel to the plane of failure.

Stress: In a solid, the force per unit area, acting on any designated plane within it.

Strike-slip fault: Fault in which movement is principally horizontal. (See Right-lateral movement and Left-lateral movement).

Plastic deformation: A permanent change, excluding rupture, in the shape of a solid.

Reverse fault: A steeply to slightly inclined fault in which the block above the fault has moved relatively upward or over the block below the fault.

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2 January 1975

Mendocino County Planning Commission
Court House
Ukiah, California 95482

Gentlemen:

We have prepared this report pursuant to our contract to provide interim guidance to the County with regard to seismic hazards and risks and to meet the State requirement for a Seismic Safety Element to be adopted as part of the Mendocino County General Plan.

This is an initial document rather than final document. Our original proposed work program for the County provided for considerably more analysis in depth of the complex geological and seismic features with substantial technical contribution from FUGRO, a geologic consulting firm. However, following a meeting with the Planning Committee of the Board of Supervisors early last year, it was decided it was advisable to alter priorities and shift a major portion of the budget to the Area Plans.

The report has been reviewed by the United States Army Corps of Engineers, San Francisco District which has made some descriptive suggestions applicable to the research and background sections of this report. These are on file with the planning department and are given due consideration.

One correction only applies to the section of the report which constitutes the actual initial Seismic Safety Element for adoption. This is on page 20. The last sentence in the first paragraph should read, "California law states that in no case can structures be located across an <u>active</u> fault trace," rather than "a fault trace."

Two other important points are made in the Corps' review. First, additional mapping of faults is being done and, in fact, some such mapping has been

completed very recently. Thus, a new map should be prepared for the Seismic Safety Element as information becomes available. Second, the Corps agrees with the Consultants that more detailed geologic work must be done for specific development proposals and to ensure that regulations for Seismic Safety are truly comprehensive and adequate for the future. We are grateful for the Corps' careful review of the report and recommend the County work with the Corps in a more comprehensive seismic research program in the future.

The report presented at this time contains background information and discussion as well as the Initial Seismic Safety Element. The Element for adoption consists particularly of pages 20 through 22 and the map of Geologic Hazards following page 22. This provides the interim advice needed and recommends policies, general approaches and regulations needed in the short range future. It should be reviewed and adopted promptly.

We wish to thank all the County staff members and the Planning Director, Ronald Hall who have assisted us in the preparation of this report.

Sincerely,

Sydney H. Williams
SHW:ji